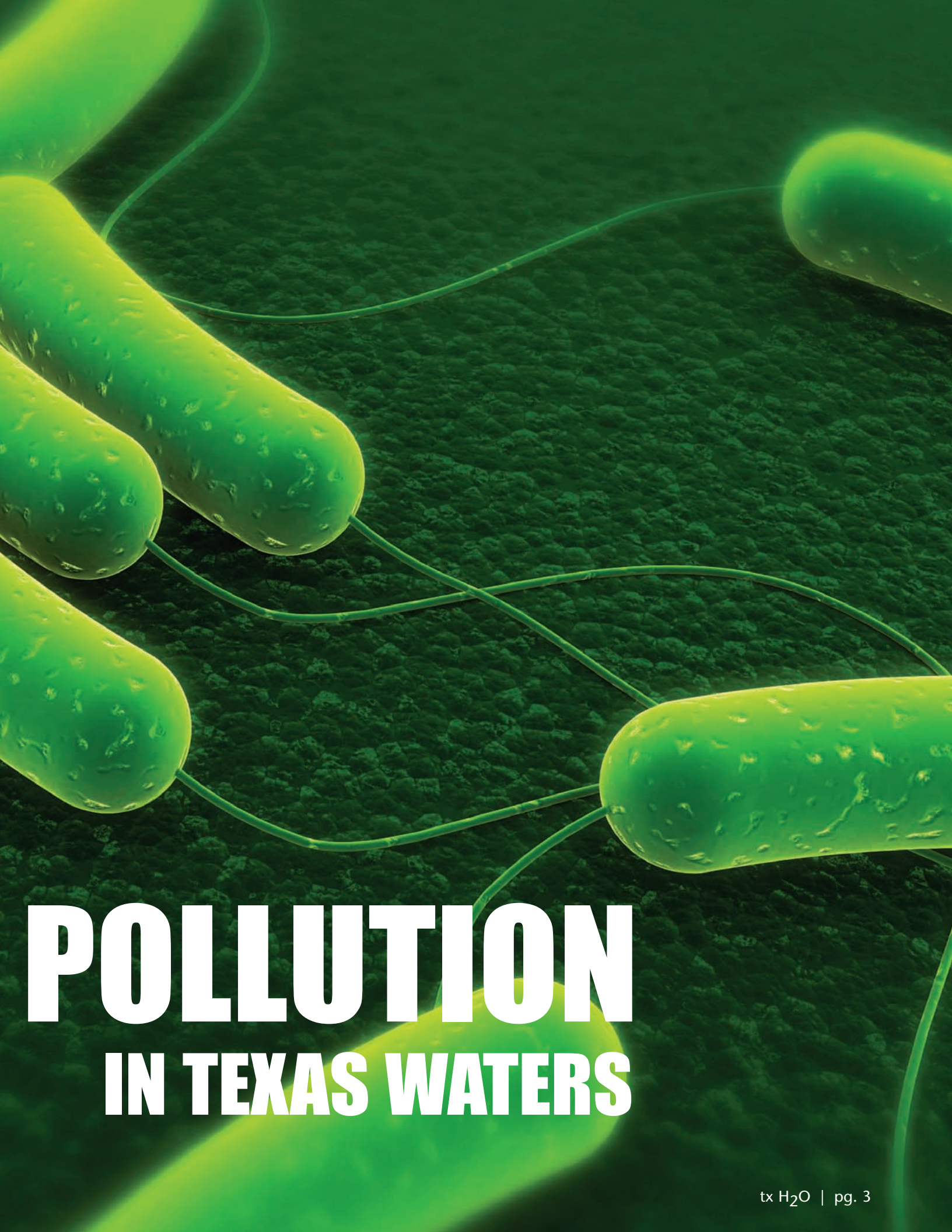
Story by Kathy Wythe

MANAGING BACTERIA



POLLUTION
IN TEXAS WATERS

With 310 water bodies in Texas failing to meet water quality standards because of bacteria, managing bacteria pollution is commanding the attention of water agencies, researchers and stakeholders across Texas.

These water bodies are listed in the *2006 Texas Water Quality Inventory and 303(d) List* for failing to meet the standards designed to protect for contact recreation use and/or oyster water use. Updated every two years by the Texas Commission on Environmental Quality (TCEQ), the number of bacteria-impaired waters increased from 197 in 2004 to 310 on the 2006 list.

"Bacteria pollution is the No. 1 cause of impairment in Texas," said Kevin Wagner, a Texas Water Resources Institute (TWRI) project manager involved in projects addressing bacteria impairment.

Although other pollutants such as metals and nutrients cause problems, bacteria pollution currently accounts for about 57 percent of the polluted waters in Texas.

"Controlling bacteria is necessary to support the recreational use of surface water and protect humans' health from illnesses caused from waterborne pathogens," said Thomas Weber, water programs section manager of TCEQ's Chief Engineer's Office.

The first step in managing this pollution is identifying the waters that are contaminated. TCEQ, along with other federal, state, regional and local agencies, continually monitors and evaluates the state's water.

To determine bacteria impairment, water managers measure *E. coli* for freshwater and *Entercocci* for salt water as indicators of the possible presence of pathogens that may cause illnesses. Bacteria in the water may come from waste from humans, livestock, pets and/or wildlife and can find their way into the water through stormwater runoff from the surrounding land, inadequate wastewater treatment and failing septic systems.

Once a water body or water segment is designated as impaired, the federal Clean Water Act requires the state to either 1) develop a total maximum daily load or TMDL, 2) conduct a use attainability analysis to change the water quality standard, or 3) collect additional monitoring data to verify the impairment. A TMDL determines the amount of a pollutant a specific water body can receive and still meet the water quality standard; it also provides numeric estimates of how much the pollutants must be reduced. Once a TMDL is completed and approved, its implementation plan or I-Plan, outlines specific measures to reduce the pollution.

TCEQ and Texas State Soil and Water Conservation Board (TSSWCB) collaborate with other state agencies, universities, companies and stakeholders in the watershed to develop these TMDLs and I-Plans.

TCEQ currently has 17 TMDL projects addressing 114 impairments to recreational and oyster water uses.

As the first bacteria TMDLs were completed in Texas, Wagner said a number of stakeholders expressed concerns over the appropriateness of the bacteria water quality standards, inadequate communication about ongoing TMDLs, and the need for better and more consistent methodologies, tools and science to develop bacteria TMDLs.

To help find answers to these issues, TCEQ and TSSWCB established a joint task force in September 2006 to identify the best and most cost-effective and time-efficient tools for developing bacteria TMDLs and TMDL I-Plans. The seven-member task force, chaired by Dr. Allan Jones, TWRI's director, was charged with making recommendations on effective methodologies and including a science road map to reduce uncertainty in what is known about how bacteria behave under different water conditions in Texas.

The task force report examined bacterial source tracking (BST), an emerging assessment tool that uses DNA fingerprinting and antibiotic resistance typing methods to differentiate between wildlife, pets, livestock or human sources of fecal bacteria, such as *E. coli.*

"BST provides valuable information that will help develop management strategies to address bacterial

contributions from specific human and animal sources of fecal pollution in each watershed," said Dr. George Di Giovanni, an environmental microbiologist at The Texas A&M University System Agricultural Research and Extension Center at El Paso and a task force member. Di Giovanni is one of the researchers at the forefront of developing BST and part of the research team that won the 2007 Texas Environmental Excellence Award in Agriculture for its BST work.

In one of the first studies completed in Texas, Di Giovanni and his postdoctoral student, Dr. Elizabeth Casarez, along with Dr. Suresh D. Pillai of Texas A&M University and Dr. Joanna Mott of Texas A&M–Corpus Christi used BST to investigate bacteria contamination in Lake Waco and Lake Belton and portions of major tributaries to those lakes. They developed libraries for thousands of *E. coli* bacteria and used these libraries to identify the sources of fecal pollution contaminating the water.

Their research in the Lake Waco/Belton project, coordinated by the Texas Farm Bureau and funded by TSSWCB through a Clean Water Act grant, showed that 40 percent to 49 percent of the *E. coli* bacteria came from wildlife sources in these particular waters, followed by cattle and then humans.

As this was one of the first studies of its kind in Texas, a secondary objective was to evaluate several analytical methods to identify the optimal method or combination of methods for future BST application.

The combination of two DNA fingerprinting techniques or a DNA fingerprinting and an antibiotic resistance typing method appeared to be the most suitable, accurate and economical for future library-based BST studies, Di Giovanni said. In addition, a new technique, which provides presence/absence detection of ruminant, human, horse and pig fecal pollution, will be used in future studies to corroborate the library-dependent *E. coli* results.

Another scientific method used in managing bacteria pollution and developing TMDLs is predictive

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Portions of Gilleland Creek in northeastern Travis County do not meet water quality standards for contact recreation use because of elevated bacteria. The Lower Colorado River Authority worked with TCEQ to coordinate public involvement, collect additional data and determine the sources of the impairment. TCEQ recently approved the TMDL. *(Photo courtesy of TCEQ)*

computer models. Researchers and water managers use these fate and transport models to identify pollution hot spots and to estimate the reductions needed to meet water quality standards. Models range from simple mathematical models to more complex hydrologic water quality models.

Dr. Hanadi Rifai, professor in University of Houston's Department of Civil and Environmental Engineering and a task force member, said models are important for a number of reasons.

"They improve our understanding of the system," she said. "They are used to answer 'what if' type questions and are tools to help managers, decision makers and stakeholders make informed decisions. They are also used to examine possible scenarios and their predicted outcomes.

"Selecting a model or models is critical in the TMDL and I-Plan process," Rifai said. "But selecting the appropriate model or models is a challenge since numerous ones are available. The different goals of TMDL and I-Plan development may require the use of different bacteria models with different levels of complexity."

Since one of the issues raised with developing TMDLs was the uncertainty associated with the modeling results, much work is being done to improve them. The models should continually evolve as the knowledge base used in developing them changes, Rifai said.

Other issues that are not well represented in the models and need to be addressed are in-stream sediment settling and resuspension processes, and bacteria regrowth and decay.

Harris County is beginning to work with TWRI and Texas A&M scientists and other university faculty to determine if *E. coli* can proliferate and grow in the waters downstream of its Houston wastewater treatment plants.

"Through this research, the group will be testing the ability of *E. coli* to survive and regrow once it enters water bodies," Jones said.

Identifying the source and amount of the bacteria is crucial, but more important is cleaning up the waters once the pollution source is known.

As part of its Statewide Bacterial Water Quality Impairment Reduction Initiative, TSSWCB, which maintains a lead role in TMDL development when agricultural nonpoint sources are involved, is currently funding about 15 bacteria-related education, assessment, demonstration and implementation projects, including four managed by TWRI. These projects account for about a fourth of its funded nonpoint source projects, said Aaron Wendt, TSSWCB's state watershed coordinator.

All agree that early and active stakeholder input and participation is essential to the success of cleaning up Texas waters from bacterial pollution.

"Stakeholder input is important throughout the entire process of TMDL and I-Plan development," Weber said. "Entities within the watershed have a vested interest in controlling pollution and protecting human health from waterborne disease."

More importantly, Weber said, stakeholders are the ones responsible for applying the measures to reduce inputs from the controllable bacteria sources. The success of a particular I-Plan will rely on these efforts.

Wendt, who said TSSWCB works closely with agricultural producers and cattlemen as well as commodity groups, agreed.

"We need to provide stakeholders the information they need to make informed decisions about managing the water resources in their watershed," he said. "Whether stakeholders are wastewater treatment plant staff or cattlemen, they are the ones who are going to be affected."

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